Wahl

HEAT-PROBER DIGITAL THERMOMETER

INSTRUCTIONS AND WARRANTY MANUAL

Models 392 & 700

WILLIAM WAHL CORPORATION
LOS ANGELES, CALIFORNIA, USA

REVISION B
W2401

1.0 INTRODUCTION

The Digital Heat-Prober is the most modern instrument for measuring temperature. It provides the certainty of reading a digital display and the precision of 0.1^{o} increments. Heat-Prober is a complete instrument in that it has its own battery power supply and recharger with probes and retractible cable designed for rapid sensing.

The Heat-Prober uses a unique electronic resistance measuring network which can be used with both platinum and thermolinear thermister probes. The platinum measurement incorporates a continuous linearization.

The LED display has a high brightness and optical magnification for good readability in all light conditions. To minimize power drain, the display is multiplexed.

A large portion of the circuit is designed with low power C-MOS circuits. The result is a design which provides a low power drain operation, which allows operation on rechargeable batteries for a continuous 4.5-hour period or more.

Qualification Tests

This instrument has been extensively tested under temperature environments from -40 to $+140^{o}F$, subjected to 4-foot drop test, battery life test and running life tests.

Mean time between failure is based on using preburned in C-MOS electronic components and is rated at 2,000 hours.

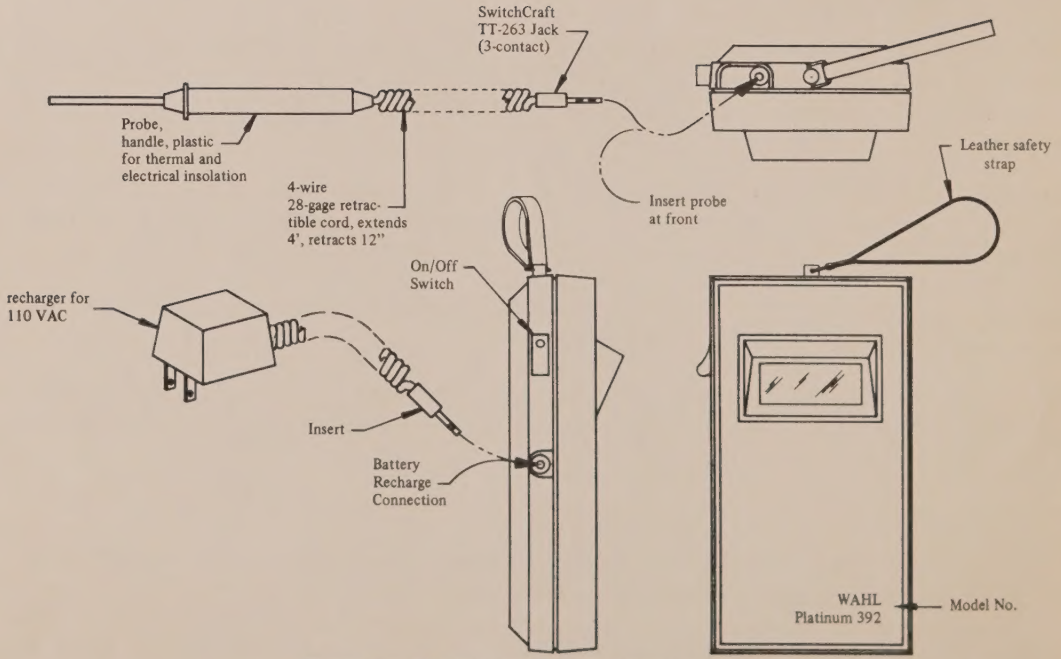

Figure 1 — Digital Heat-Prober Major Features

2.0 TO OPERATE

Insert probe into jack at front left. Turn on the switch at the left. White dot on switch is the "ON" position. Depress the white dot for "ON". The room temperature should be displayed in ^{o}C or ^{o}F. If all 8's appear, or if there is no reading, this indicates the battery is discharged. Recharge the unit by inserting the recharger in any 110 VAC, 50-60 Hz wall outlet and plug in the recharger jack to the instrument socket on the left. (Turn the instrument switch OFF during recharging, as this will draw current for the display. Charge for 6-7 hours.) Turn on instrument again.

Make measurements with sensor probe as required. Turn off switch when measurements are complete to preserve battery life.

2.1 Meter Operation

The digital readout will show 0.1^{o} increments from -50 to $140^{o}C$ (or -60 to $284^{o}F$). Over $140^{o}C$ or $284^{o}F$, the instrument automatically ranges to single $1^{o}F$ or $1^{o}C$ increments.

This is done to be consistent with accuracy capability of the sensor instrument in the higher temperature ranges where 0.1 increments are not significant.

When returning from above to below $140^{o}C$ (or $284^{o}F$), the instrument will automatically begin to read in 0.1^{o} increments again. The specific point at which this auto-ranging occurs may vary from 135 – $145^{o}C$.

2.2 Automatic Polarity

When the temperature sensed is below zero, a minus sign will automatically show the digital display. Absence of a sign indicates positive temperatures.

2.3 Digital Display and Accuracy

The characteristic of digital readouts is a flicker in the least significant digit. In this instrument, you can expect to see a 1-digit flicker, particularly when reading 0.1 increments. Variations over ±0.1 will be attributable to sensor temperature changes.

2.4 The Batteries

The Heat-Prober is powered with rechargeable nickel-cadmium batteries. There are 5 batteries, 1.25-volt each, size AA. The total capacity is 450 – 475 milliampere hours at 6.0 volts. The batteries power the instrument for a minimum of 4.5 hours, and as much as 6 hours, depending on the number of digits being displayed. (The display demands the largest power drain.)

2.4.1 Recharging

To recharge the batteries, use the recharger supplied. Plug in directly to 110V 60 cycle wall plug and insert jack into socket on left side of Heat-Prober. (For overseas 220-volt lines, use a Franzus converter adapter with the recharger supplied or request a 220-volt recharger.)

2.4.2 Continuous Operation

The Heat-Prober can be continuously operated by using a battery recharger to restore or recharge the batteries as rapidly as they are depleted. The instrument operates from the batteries only.

NOTE: The instrument cannot rectify AC current. A DC voltage of 7.5 volts and approximately 120 milliamperes will maintain the battery charge. This occurs when the switch is on and the instrument is operating.

The recharger will charge the batteries with the switch "OFF," or make-up battery power, when the instrument is operating. The recharger supplied with the instrument will enable continuous operation, depending on the number of digits being displayed. The recharger will make up a fixed drain up to 120 milliamperes. The instrument will normally draw 75 milliamperes, but for readings of say 202.2°F, will draw 100 milliamperes, because of the configuration of the digits.

3.0 PROBES

There are two Heat-Prober models: Model 392 for platinum sensor, and Model 700 for thermister sensor. This number is printed on the front plate of the meter. The probes are all interchangeable at 0°C within the accuracy description of the units as follows:

	Model 392	Model 700
	Interchangeability at 0°C	
Surface Probe	±0.5°C	±0.2°C
Immersion Probe	±0.3°C	±0.2°C
Air Probe	±0.5°C	±0.2°C

	Model 392	Model 700
	Interchangeability at 0°C	
Clamp-on, metal	±0.5°C	–
Stick-on	±0.5°C	–
Clamp-on, ceramic	±0.3°C	

See Table 1 for interchangeability at other temperatures.

These inaccuracies are the result of tolerances in the making of sensors. The instrument is set up at the factory to match at 0°C, 100°C, 400°C by simulating resistance with a decade resistor box input in place of the probe. Thus, the tolerance variation is due to the sensor tolerance.

For better accuracy, it is possible to adjust the zero and span of the instrument to the exact probe. This requires accurate control 0°C, 100°C or other desired calibration temperature, and adjustment of zero and span potentiometers. (See Section 7.3.4.)

The probes/sensors are designed for your convenience. A handle made of plastic is assembled to each probe with a retractible cord for each use without entangling. The handle is made of high quality ABS plastic, which reduces thermal influences of the hand on the probe sensor, and isolates the hand from temperature and electrical potential. Each probe is tagged with its part number and type.

4.0 TEMPERATURE SENSORS IN USE

Everyone can understand putting a thermometer in fluid and after a time, getting a stable temperature. Even this measurement, to get a good representation of the fluid, requires continuous stirring and mixing, and some time to occur.

Measurement of surface or air temperature requires an understanding of heat transfer. The sensor measures its own temperature; therefore to measure a body temperature, it must be brought to that body temperature by good contact.

For a portable probe temperature sensor, it must have these characteristics:

(a) A low thermal mass (product of its specific heat and weight)

(b) A large area for surface contact (to permit the heat from the object being measured to flow through to the sensor).

(c) A minimum heat conduction away from the sensor (which will reduce its temperature below the object, and create an inaccuracy).

The WAHL surface probes are designed with the above three conditions as criteria, and also include an insulating handle which,

(a) Thermally isolates the hand from the probe, either preventing hand heat from reaching the sensor, or sensor heat, in the case of a high temperature measurement from burning the hand.

(b) Electrically isolating the hand from the metal probe and therefore, potentially, from a voltage on the surface to be measured.

For surface measurements, to obtain best time responses and accuracy, two things are necessary:

(a) Good surface contact with all of the probe surface. Make sure of this by holding it squarely on the surface.

(b) Use a film of silicone paste on the probe tip to assist in making contact and aiding heat transfer.

In liquids, move the immersion probe around and mix to get good contact. In air, put the probe in the vicinity to a stream to get good velocity, otherwise move the probe back and forth to induce velocity across the tip.

For the bolt-on or stick-on probe/sensors, it is recommended that an insulating layer of cement be placed over the unit after installation to prevent heat loss to the surroundings.

A rough surface gives poor heat conductance to the measuring probe. This can be overcome by using a few drops of heat conducting silicone paste between the measuring point and the probe tip. The paste shortens indicating time up to 50%.

5.0 SPECIFICATIONS, Model 392 Platinum

Temperature Measurement Range	-50 to 500°C or -50 to 900°F
Indication	LED Display shows 0.1°F or °C increment
Auto-Range	Reads to 0.1°C or °F from -50 to 284°F approx. Over 140°C or 284°F, the 0.1 digit is dropped for a least significant whole number digit. Return below brings back the 0.1 digit.
Accuracy, at 25°C	±0.5% ± 1 digit
Environmental Temperature Range of Operation	-20 to +50°C (0 to 120°F)

Temperature Coefficient	-.02°C/°C ambient change
Repeatability (ability to measure the same temperature)	±0.2° ± 1 digit
Probe Connection	SwitchCraft TT-253 mates
Measurement Sensor/Probes	Platinum resistance 100 ohms at 0°C .00385 ohm/ohm/°C.* (For thermister probe, see Model 700 unit.)
Type of circuit	Unique patented circuit simplifies the sensors of resistance changes in the probe. Continuous linearization compensates for the non-linearity of platinum over 284°F.
Update Rate	3/sec.
Digital Display	LED display for digits automatic minus and decimal point. Battery low flashes all 8's.
Power requirements	5.0 volts DC at 75 milliamperes
Batteries	Rechargeable Nickel Cadmium batteries, AA, 6.0 volts
Recharger	7.5 volt DC at 75 ma output from 110 VAC
110 V Line Operation	With recharger plugged in and switch "on", operates from battery.
Battery life without recharge	4.5 hours
Recharge time standard	6 - 7 hours
Physical:	
Weight	10.5 oz. (280 gms)
Dimensions	6" long x 1" high x 3" wide

*For all units manufactured after May 30, 1975.

Operation:	It is only necessary to plug in the probe and turn the switch on. If the batteries are low, the display will show 8's. Otherwise, proceed with measurements. Turn off between measurements and when ready to stow instrument.
On/Off Switch	Positive feel, over center toggle with white dot indicator for "on."

SPECIFICATIONS, Model 700, Thermister

All specifications for Model 392 apply, except for the following:

Measurement Range:	0 to 100°C in 0.1°C increments (also 32°F to 212°F in 0.1°F increments)
Auto-Range:	None
Linearization:	None Required
Measurement Sensor/Probe:	Thermo-linear thermisters

6.0 DESCRIPTION OF OPERATION

The WAHL Digital Thermometer uses a platinum resistance or thermister probe as its temperature sensing element. The probe resistance is continually compared to a fixed resistance whose value is equal to the probe resistance at zero degrees C or F depending on the temperature range desired. A count is generated in direct proportion to the resistance difference between the probe and fixed resistance and stores in a four-decade counter. This occurs approximately three times per second. The nonlinearity of the platinum probe is corrected by increasing the accumulated count in direct proportion to the resistance difference mentioned above. The contents of the four-decade counter is repeatedly fed through a decoder/driver in a sequential manner to drive the LED display. This multiplex operation results in both a power and component savings. The polarity of the temperature is automatically determined by a comparison circuit that senses whether the probe resistance is greater or smaller than the fixed resistance and drives the sign segment for negative

temperatures only. No polarity indication is assumed to be positive temperature. The unit also contains a voltage regulator and a low-voltage sensing circuit. The voltage regulator maintains a constant 5 VDC for certain portions of the circuitry and the low-voltage sensing circuit drives the display to all 8's when the battery voltage has been discharged to approximately six volts. There are five adjustment potentiometers that are used to properly adjust the unit upon checkout. One adjusts the regulated voltage, two adjust the zero and gain readings and the remaining two adjust the linearization network. The latter two are not required on the Model 700.

All logic circuits are implemented using the new C-MOS family with an average power dissipation of approximately 450 milliwatts with three digits being displayed.

7.0 CALIBRATION/REPAIR

The best way to check the functioning and calibration condition of the Heat-Prober is to use the WAHL accessory calibrator, P/N 10382, which plugs right into the probe connection and provides the 4-key calibration input. See figure 2.

The Heat-Prober instrument may be repaired, for minor items, recalibrated, or adjusted for a particular probe in the field by following the directions below. However, it is recommended that calibrations and repair be conducted at the factory. Send the Heat-Prober back in its foam package with a description of the symptoms, and a repair estimate will be made for your approval.

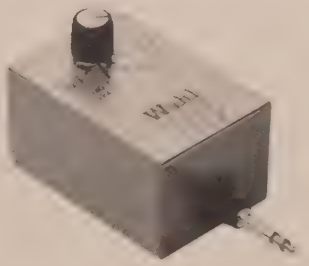

Figure 2 – Heat Prober Calibrator

7.1 Equipment Required

Digital Voltmeter

Decade Resistance Box to 1000-ohm in 0.01-ohm increments (for thermister Model 700, 100,000 ohms in 1-ohm steps).

7.2 Disassembly

The instrument is held together by 4 screws removable from the bottom. When these are removed, the top cover is released. Be careful, as this also releases the 2 printed circuit boards. The 2 boards are separated by insulated standoffs. Once the screws are removed, these fall out and must be saved for reassembly.

Take out the lower board and unfold it outside the case. The wires are long enough to allow this. (See Figure 2.)

7.3 Diagnostic/Trouble Shooting

7.3.1 If you suspect a dead battery (because it won't recharge, or once recharged, won't stay on very long):

(a) Check the battery voltage with a DVM through a 15-ohm load on the batteries. If the voltage drops rapidly, it indicates fault in the battery.

(b) Remove the 2 screws in the green battery hold-down plate.

(c) Replace with 5 AA Ni-Cad batteries. Solder together in series to achieve 6 volts or more.

(d) Set up the unit in accordance with Procedure 7.3.4.

7.3.2 If the unit works, but appears to be out of calibration, proceed as identified below in Procedure 7.3.4.

7.3.3 If the unit doesn't work at all, or if you have gone through Procedure 7.3.1 and 7.3.2, return the unit to the factory.

7.3.4 Calibration Procedures, Platinum

(a) Calibration — Electronic

You will need certain items to make an electronic calibration of the Digital Heat-Prober. There are:

Decade Resistor, 1K ohms in .01-ohm steps.

Voltmeter, 0–10 VDC

This is not a difficult or time consuming procedure, but care must be taken in handling the electronic boards particularly in regard to breaking wires.

Once the circuit boards are out of the case, you will notice that all components are identified by symbols printed on the circuit board. These will be referenced in this procedure. (See Figure 2.)

Basic Theory: Platinum has a well defined resistance versus temperature curve. Accordingly, if a decade resistor is put in place of the probe to simulate the standard platinum element, a quick calibration can be made. It must be kept in mind that allowance for lead resistance must be made (added) to the decade box resistor which simulates the platinum sensor. Thus, 100.0 ohms for 0.0°C calibration will be 101.0 ohms, the 1.0 ohm extra for this model is the measured allowance for the probe coil cord and connections of the probes.

Turn unit on. Follow this procedure:

(1) *Set battery voltage.* Connect, with electronic probes, a D.C. voltmeter to Z16 (small board) emitter (fourth pin) and the negative side to the battery common wire point (designated E4 on the small board). Adjust R2 on the small board (single turn potentiometer) until the voltmeter reads 5.0 ± .05 volt. This sets the undervoltage trip point of the battery power supply.

(2) *Calibrate 0°C point.* Connect the decade resistance box to the circuit. Connection by short low resistance leads (< .01 ohm) is necessary. Connect to the two internal leads of the probe jack in the meter housing. Connect to E3 and E1 on the small board. Set the resistance at 101.0 ohm. (Add 1.0 to Table value.) Adjust R15 (20-turn potentiometer on small board) until the display reads 0.0°C or 32.0°F.

(3) *Set the 100°C (or 212.0°F) point.* Adjust the variable resistance to 139.5 ohms. Adjust R12 (20-turn potentiometer on small board next to R15) until the display reads 100.0°C or 212.0°F.

(4) Go over steps (1), (2) and (3) until satisfactory readings for all points are established without further adjustment.

(5) *Set the linearization circuit.* This is the point where the decimal point drops out as it is insignificant above 140°C. It is also the point at which linearization circuit is cut in for the linearization of the platinum curve in the higher temperatures. Adjust R33 fully counterclockwise. Adjust the input resistance to 154.57 where the display reads 140.0°C or 284.0°F. Then adjust R33 clockwise until the display drops the decimal point, and by small adjustment of the R33, the decimal can be made to move in and out of the display. This is the correct setting.

(6) *Set the high point calibration.* Adjust the input resistance to 247.5 ohms. Now adjust R26 (single-turn potentiometer on large board) for a reading of 400°C (or 752°F).

(7) This completes the electronic calibration. A second run-over of the six steps will assure all settings are correct.

(8) See Table 1 for nominal platinum resistance and interchangeability.

(9) Reinstall all elements into the box. Make sure that the bottom board is not cocked or pressing against the case.

(b) Calibration Procedure — Thermal

For thermal calibration, baths are needed (for immersion probes) and surface plate for surface probes. DO NOT calibrate a surface probe by immersing. There will be an error because compensation is made at the factory for heat loss in surface probes.

Insert the probe in the unit and into well stirred, controlled heat baths at 0°C. Do not just use an ice water mixture. The temperature can vary ±1°C, depending on the layer of water the probe is in, or proximity to a piece of ice.

With the instrument apart as indicated above, adjust R15 until a 0.0 reading is obtained. Then, if available, calibrate at 100.0°C, or boiling part of water as above in Step (3).

With the instrument apart as indicated above, adjust R12 until a 100.0 (212.0°F) reading is obtained.

For span, a 300°C, or higher bath, should be used. Adjust R26 until the temperature reading is achieved.

It is not necessary to readjust zero after a span adjust.

7.3.5 Calibration Procedure, Thermister

Same as in Procedure 7.3.4 except, connect a resistance value as follows for adjusting zero and span: For R15, adjust to 0.0°C with 20,516 ohms, for R12, adjust to 100.0°C with 1,578 ohms into the probe jack. No linearization adjustment is required.

For electrical calibration, the resistances are most conveniently attached inside the probe jack, while the case is open. Across the top two connections of probe jack (across 3200 ohm resistance), attach the following resistances.

For Temperature Reading	Resistance	
0.0°C	20,516 ohms	Adjust R15
100.0	1,578 ohms	Adjust R12

Actually, the best way is to make an ice-water bath and a boiling water bath with at least 6-inch depth and make the potentiometer adjustments with an immersion probe with the instrument.

With these resistances installed, adjust trimpots noted for the proper reading on the display. This provides a rough calibration. The final calibration should be with the probe in an ice bath and a well-stirred boiling water bath.

8.0 ACCESSORIES

Leather Safety Strap	$5.00
Silicone Paste	3.00
Battery Recharger, fixed output, 120 MA 120 V, 60 cycle (replaces standard unit)	6.00
Battery Recharger, 220V, 50/60 cycle European connection	10.00
Instrument Kit Case, holds meter, recharger, 2 probes, calibrator, in urethane foam.	$35.00
Extra Batteries, AA, nickel-cadmium (5 required)	15.00/lot
Carrying Case, for meter, hand strap and belt clip	10.00
Calibrator - 4-point, plugs into probe connection.	75.00

9.0 CALIBRATION

Recalibration service can be provided at a nominal cost of $30.00, if desired. Special calibration traceable to NBS is $45.00.

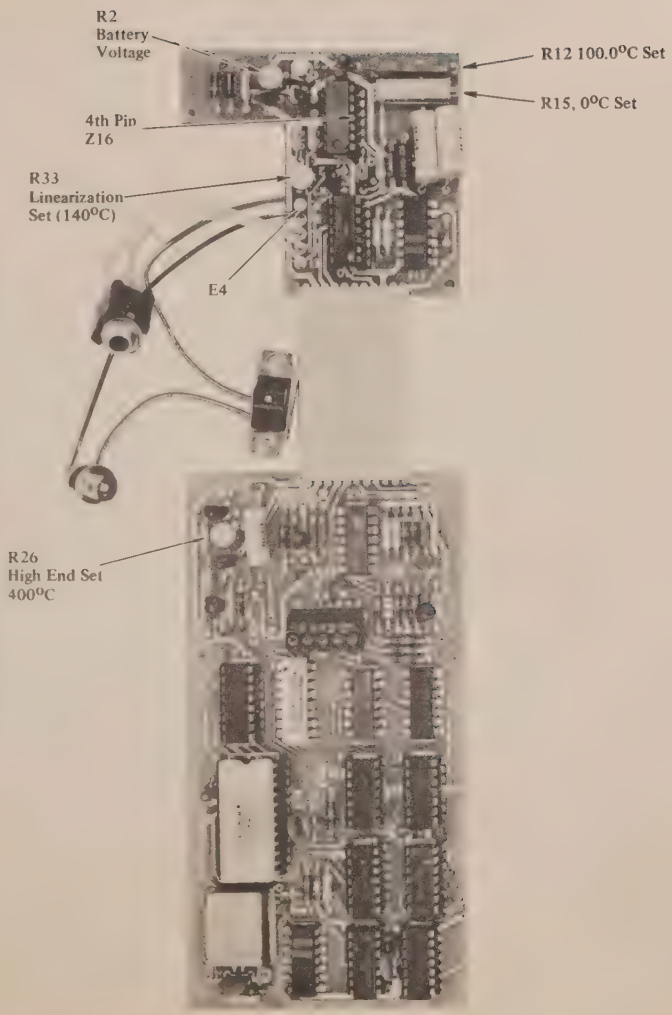

Figure 3 — Complete Digital Heat-Prober Electronics

Table 1

INTERNATIONAL RESISTANCE VS TEMPERATURE — IPTS-68, DIN43760

(For .00385 Ohm/Ohm/°C Platinum)

DEGREES C	0	-10	-20	-30	-40	-50	-60	-70	-80	-90	-100
0	100.0	96.09	92.16	88.23	84.29	80.32	76.34	72.35	68.34	64.32	60.28
DEGREES C	**0**	**10**	**20**	**30**	**40**	**50**	**60**	**70**	**80**	**90**	**100**
0	100.00	103.90	107.79	111.67	115.54	119.40	123.24	127.07	130.89	134.70	138.50
100	138.50	142.29	146.06	149.82	153.57	157.31	161.04	164.76	168.46	172.16	175.83
200	175.83	179.50	183.16	186.82	190.45	194.07	197.69	201.29	204.88	208.46	212.02
300	212.02	215.58	219.12	222.66	226.18	229.69	233.19	236.68	240.16	243.61	247.08
400	247.08	250.52	253.95	257.37	260.77	264.17	267.56	270.94	274.29	277.64	280.98
500	280.98	284.31	287.63	290.93	294.22	297.50	300.76	304.02	307.27	310.51	313.72

TOLERANCE (Probe Interchangeability)

Temperature (°C)		-250	-220	-200	-100	0	100	200	300	400	500
Tolerance	(±°C)	5.8	1.8	1.2	0.7	0.3	0.5	1.1	1.7	2.3	3.0
	(±Ω)	1.0	0.7	0.5	0.3	0.1	0.2	0.4	0.6	0.8	1.0

DEGREES F	0	-20	-40	-60	-80	-100	-120	-140	-160	-180	-200
0	93.03	88.65	84.26	79.85	75.42	70.98	66.52	62.04	57.54		

DEGREES F	0	20	40	60	80	100	120	140	160	180	200
0	93.03	97.39	101.74	106.07	110.38	114.68	118.97	123.24	127.50	131.74	135.97
200	135.97	140.18	144.38	148.57	152.74	156.90	161.04	165.17	169.28	173.38	177.47
400	177.47	181.54	185.60	189.64	193.67	197.69	201.69	205.68	209.65	213.61	217.55
600	217.55	221.49	225.40	229.31	233.20	237.07	240.93	244.78	248.61	252.43	256.23
800	256.23	260.02	263.80	267.56	271.31	275.04	278.76	282.46	286.15	289.83	293.49

TOLERANCE (Probe Interchangeability)

Temperature (°F)		-420	-400	-350	-300	-200	-100	0	32	100	200	300	400	500	600	700	800	900
Tolerance	(±°F)	10.4	8.3	3.3	1.9	1.5	1.1	0.7	0.6	0.7	0.9	1.5	2.0	2.7	3.3	3.9	4.5	5.4
	(±Ω)	1.0	0.9	0.7	0.5	0.4	0.3	0.2	0.1	0.2	0.2	0.3	0.4	0.6	0.7	0.8	0.9	1.0

WARRANTY

WAHL warrants all its products to be free from defects in workmanship and material under normal use and service.

If any of our products is believed to be defective as to workmanship and/or material under normal use and service and if the same is returned to the Company, freight prepaid, **within 12 months** after date of purchase and is found by the Company's inspection to be defective in workmanship and/or material under normal use and service, it will be repaired or replaced free of charge and shipped, freight prepaid, to any point in the United States. If inspection by the Company of any such product does not disclose any defect in workmanship and/or material under normal use and service, the Company's regular charges will apply. This warranty shall not apply to (1) ordinary wear and tear nor (2) any product which has been opened or modified or repaired or altered by the purchaser & (3) to any product which has been subjected to misuse, negligence or accident. The Company's obligation, under its warranty or otherwise, relative to product defects is limited to the above paragraph.

Warranty Card must be filled in and returned for above warranty to be valid.

Wahl

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